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TITLE: On the problem of the transverse stability of charged beams in accumulating systems

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TEXT: Some transverse space-charge effects in cyclic systems, especially the nonlinear isoenergetic oscillations of particles in the radial direction of a beam, are studied. In a linear treatment of this problem (A. A. Kolomenskiy, A. N. Lebedev. CERN Symposium, 1959, p. 115) no account is taken of the nonlinear effects of the "negative mass". The amplitude of the radial oscillations $\ddot{x} + \omega^2 x = g_1 x^2 + g_2 x^3 + (e\mathcal{E}/m\omega\gamma^2)$ is assumed to be great enough to excite nonlinear effects. $\mathcal{E}$ denotes the field of the fluctuations, $\gamma = E/E_0$, E is the total particle energy. The amplitude A and the phase φ of these nonlinear oscillations depend on time to a relatively slight extent. The perturbation $f \ll F_0$ in the distribution func-

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tion $F = F_0(z) + f(t,z,\varphi)$ for the state of the beam satisfies a linear kinetic equation. The solutions of the dispersion relation resulting from this kinetic equation determine the asymptotic behavior of the perturbations. F_0 is the equilibrium distribution which is homogeneous with respect to the phase. The study of the perturbations uniformly distributed in the vertical sense is significant for every interval of x and φ. The two kernels of the integral equations for f correspond with the two extreme cases where the dimensions of the perturbations along the beam axis are much greater or much smaller than the radial dimensions of the beam. The frequencies p of the plasma oscillations for a given $F_0(z)$ follow from this integral equation. With an accuracy of $(\Delta z/z_0)$, the formulas

$$p = ik\beta z = ik\psi\left(1 \pm \sqrt{1 - 8\beta z_0/\psi}\right), \quad \psi = \frac{e^2 N \left| I'_{00}\pi/k \right|}{8\pi m\gamma^3\omega\sqrt{z_0 y_0 R}}$$

are obtained for the first type of perturbation. For $\beta > 0$ the distribution is always unstable, for $\beta < 0$ the density performs small steady oscillations of the frequency, determined by Imp. For this case, $\beta = 5g_1^2/12\omega^3 + 3g_1/8\omega$. The duration of th

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the development of the instability in an electron accumulator with $\gamma = 60$, $R = 10^2$ cm, $N = 5\cdot10^{13}$, field index n = 2/3 has the value of $T \sim 1/p \sim 10^{-7}$ sec which is of the order of several revolutions. The phenomenon discussed here has to be taken into account in the accumulation of particles, in reactions in opposed beams, during an injection, etc. It can also be used for the self-control of beams.

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